TENTH MONTHLY REPORT

for

A MINIMUM-NOISE, LOW TEMPERATURE
COOLED PARAMETRIC AMPLIFIER SYSTEM
WITH A SIMULATED CLOSED-CYCLE
REFRIGERATOR SYSTEM

1 APRIL 1965 - 1 MAY 1965

CONTRACT NO. NAS5-9046

PREPARED BY

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for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
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Objective

The objective of this contract is to develop and furnish to Goddard Space Flight Center an advanced state-of-the-art minimum-noise, low temperature, cooled parametric amplifier system, associated spare parts, and engineering manuals in accordance with NAS-GSFC Specification PCN70621, dated 15 May 1965 and Modification No. 1 to Contract No. NAS 5-9046.

An additional objective is to provide equipment flexibility that allows alternate operation at 4.2°K in a simulated closed cycle (liquid helium, open dewar) cooling system.

Summary of Work

The work conducted during this period consisted of diode evaluation, parametric amplifier testing, fabrication of piece parts for the control panel, pump assembly, cold load, and paramp monitor.

1. Parametric Amplifier Development

The RCA varactor diodes were received during the month of April. Several of these diodes were evaluated for figure of merit. The figure of merit of the varactors tested varied widely although about fifty percent of these tested were found satisfactory for broadband operation.

Four of the RCA varactors were tested cold. The results of these tests varied widely. In one amplifier, noise figures varying between 5°K and 20°K were measured on two varactors operating in liquid helium. The difficulty encountered in these measurements was due to thermal instability of the diode. This instability was caused by helium gas which was used to overcome gain instability problems resulting from direct immersion of the amplifiers into liquid helium. One of the same diodes was measured in the same amplifier with the body temperature of the amplifier at 38^{o}K. This test was made in an ADL 340L refrigerator and the gain stability and noise figure repeatability was very good. The amplifier and input line combination measured 32^{o}K. The repeatability of these measurements allowed noise temperature measurements with different bias levels and diode current levels to be made. The noise temperature quoted above was measured with 0.5 volts of back bias and 1.0 microamp of diode current. With the bias voltage set to 0 volts, the diode draws about 10 microamps of current and the noise figure measures approximately 70^{o}K. This increase in noise temperature is probably due to a change in diode series resistance between 0.5 volts and zero volts.

Two of the diodes were tested in a second amplifier which was identical to the broadband amplifier without the broadbanding stubs. The noise temperatures measured on this amplifier were extremely high for cooled amplifiers. Inbestigation into the design of the amplifier indicated two possible causes. (1) Propagation of the idler through the signal line by the TE_{01} mode, thus providing room temperature loading and (2) insufficient isolation between the pump circuit and the idler circuit thus, again, providing possible room temperature termination of the idler.

The broadband amplifiers were modified to provide better isolation in the idler circuit. The modification of the amplifiers resulted in a change in broadbanding characteristics of the amplifier. A new prototype amplifier was made to allow positioning of the signal tuning section of the amplifier. The prototype amplifier has been adjusted for broadband operation over the proper frequency range; however, the ripple within the passband has not been reduced sufficiently to allow fabrication of the system amplifier.

2. Circulators

The delivery of the helium coolable circulators is behind schedule. The previous delivery date was to be 7 May, but delivery of the circulators has been rescheduled for 24 May.

3. Paramp Monitor

The leveler circuit has been redesigned and breadboarded. Drawings are now in work to incorporate the design modifications. All piece part drawings have been completed and released for fabrication. The horizontal and vertical amplifier printed circuit boards have been assembled and are presently being tested. Final assembly of the plug-in chassis will not begin until all tests have been completed on the printed circuit boards. The scheduled completion date for the plug-in chassis is 21 May. The BWO housing is also in work. All piece parts are scheduled to be completed by 14 May. Assembly of the BWO package will begin on 17 May.

4. Input-Output Lines

The input and output lines for the refrigerator have been placed in the shop for final fabrication. All parts for the refrigerator assembly will be complete by May 26. Current tests are being run using a set of test lines which will be similar to the final lines except these lines are only designed for cooling one amplifier.

5. Cold Load Calibration

The cold load was fabricated and calibrated during the month of April.

The procedure followed was that outlined in the Appendix of MPC Drawing No. 11232 enclosed. There is one error in the derivation of the equation for calculating noise temperature resulting from line losses. Also, the waveguide was filled with foam rather than using a waveguide window. The following results were obtained:

$$L_o-1 = L_{1-2} = L_{2-3} = .0065 \text{ db} = 1.0015$$

$$L_{3-4} = .0094 \text{ db} = 1.0022$$

$$T_o = 77.37^\circ K$$

$$T_1 = 162^\circ K$$

$$T_2 = 223^\circ K$$

$$T_3 = 276^\circ K$$

$$T_4 = 298^\circ K$$

The equation used to determine noise temperature is:

$$T_e - \frac{T_o}{L_o-4} + \frac{T_o-1(L_o-1-1)}{L_o-4} + \frac{T_1-2(L_1-2-1)}{L_1-4} + \frac{T_2-3(L_2-3-1)}{L_2-4} + \frac{L_3-4(L_3-4-1)}{L_3-4}$$

So that,

$$T_e = \frac{77.37}{1.0067} + \frac{119.7(.0015)}{1.0067} + \frac{193(.0015)}{1.0052} + \frac{249(.0015)}{1.0037} + \frac{287(.0022)}{1.0022}$$

$$+ .63 + .37 + .29 + .18 + 76.86 = 78.33^\circ K$$

6. Parametric Amplifier Pump Assembly

Assembly of the unit is 80 percent complete. Scheduled completion date for the first unit is 21 May.

7. Parametric Amplifier Control Panel

Completion of the panel parts has been delayed due to delays in receiving the piece parts from a sub-contractor. The enclosure for the assembly was rejected and returned to the sub-contractor for rework. Electrical assembly will begin immediately upon receipt of the piece parts.

8. Schedule

Assembly of the control panel will be started in May. The pump assebmly and paramp monitor will be assembled and completed in May. Diode selection and amplifier design evaluation will continue.